

**Amendments to the Specification:** Please replace the pending specification (starting on page 12 through page 32) with the following replacement specification (with amendments to the specification shown with "strikethrough").

## **DESCRIPTION OF THE PREFERRED EMBODIMENT**

Embodiments of this invention are outlined below with reference to the drawings.

### **The First Embodiment**

The first embodiment of the apparatus for scarifying the interior surface of a pipeline is depicted in Figures 1-4. Figures 1-3 depict side, front and top views, respectively, of the first embodiment with the arm 7 oriented in a vertical position. Figure 4 depicts a front view of the apparatus with the arm 7 at a transverse angle. The nozzle assembly 10 of the first embodiment is depicted in Figures 8 and 9.

The apparatus comprises a vehicle 18 that is propelled along a longitudinal direction inside of a pipe, cleaning the interior surface as it travels. The apparatus is equipped with a scarifying system 19 comprising an arm 7 and a nozzle assembly 10. The scarifying system 19 extends from the vehicle to the wall of the conduit and uses nozzles to clean and scarify the interior surface of the pipe.

The vehicle 18 includes a chassis 2, which moves longitudinally along the bottom floor of the pipe on its track assembly 1. The tracks 1 are propelled along rollers 3 by a hydraulic motor (not shown) sitting on board the chassis 2. The hydraulic motor is powered by an external hydraulic reservoir (not shown) coupled to the apparatus by a hydraulic coupler (not shown) also mounted on the chassis 2. It will be noted that, although a hydraulic motor is used in this embodiment, any power providing means, both external or on-board but preferably exhaustless, may be used for this application. Alternatively, with a sufficiently light vehicle, the vehicle could also be moved manually. The direction of motion of the vehicle is that of arrow 16 or 17. An on-board battery 4 powers hydraulic switches (not shown), which control the speed and direction of motion of the vehicle. The motor, hydraulic coupler and hydraulic switches are covered with plate 5 to protect their sensitive parts from debris dislodged during cleaning. When nozzles 15 are employed to clean and/or scarify the walls of the conduit, recoil forces may tend to disturb the vehicle trajectory. Accordingly, a number of guiding bars 20 may be attached to the chassis 2 of the vehicle 18 and telescopically extend to the walls of the pipeline. The guiding bars' wall engaging attachments 21 move along the pipe's walls and prevent the vehicle 18 from deviating from its path.

The scarifying system 19 consists of a telescoping arm 7 and a fluid nozzle assembly 10. The arm 7 includes two telescoping pipes in which the upper portion of the pipe 12 has a smaller diameter such that it slides down into the

lower portion. The piston 26 controls the extension of the telescoping arm 7. This combination of telescoping parts permits the arm 7 to be extended or contracted depending on the diameter of the pipe surface to be cleaned. The arm 7 pivots on hinge 25 in a lateral direction so that it can reach any transverse angle between 0° and 180°. Consequently, the device can manipulate the scarifying system 19 so that the fluid nozzle assembly 10 is in close proximity to the pipe walls. Since this embodiment contains only one arm 7, a stabilizing bar 8 is used to counteract the weight of the arm 7 as it is extended radially.

The scarifying system 19 may be easily removed from the chassis 2 of the vehicle 18 in order to reduce the size of the apparatus so as to enter a sewer system through a small aperture such as a manhole. Furthermore, the width of the chassis 2 (i.e. separation between tracks 1) can be adjusted so as to position the vehicle 18 longitudinally in pipes of various sizes.

The fluid nozzle assembly 10 is mounted at the distal end of the arm's 7 telescoping pipes. Fluid coupler 9 with a flow control valve is attached to an external source of fluid under pressure (not shown), which is fed into exchanger/actuator 13. Referring to Figure 8, exchanger/actuator 13 causes the fluid nozzle assembly 10 to rotate or oscillate and distributes the fluid to each branch 14 of the fluid nozzle assembly 10. Arrows 22 and 23 indicate the direction of rotation. The actual fluid nozzles 15 emit jets of fluid aimed against the pipeline

walls. The fluid nozzles 15 discharge fluid to profile and clean the interior surface of the pipe. The drawings show one fluid nozzle 15 attached to each branch 14, but it should be obvious to one skilled in the art that a plurality of nozzles 15 may be coupled to each branch 14.

Referring now to Figures 4 and 13, as the vehicle 18 travels up the center of the pipe floor 27, the scarifying system 19 scarifies a swath of the pipe wall 28. The swath is approximately the same width 29 as the diameter of the fluid nozzle assembly 10 and is centered approximately at the arm angle 30. Fully scarifying the interior surface of the pipe requires that the vehicle 18 make several passes back and forth, changing the arm angle 30 with each pass. The vehicle chassis is outfitted with a drawbar (not shown), which holds the hydraulic and pressurized fluid tethers away from the apparatus so that it may easily travel forward or reverse without running over the tethers.

An additional safety feature not shown in the drawings is a "deadman" which is a safety switch operative to cut off the high pressure from the moving parts of the scarifying system 19. The deadman is useful in both emergency situations and when minor adjustments must be made to the apparatus during a job.

This apparatus is the preferred embodiment when the conduits or pipes are not perfectly cylindrical in shape (i.e. they are some other shape such as semicircular in cross section). This embodiment can also be used for a cylindrical pipe when flow diversion is impossible. A

false floor 31 is layered on top of the minimum flow mark 32 and the cleaning is performed above the false floor 31. Since most of the corrosion occurs in levels above the minimum liquid level 32, this cleaning method is acceptable for restoration applications.

### **The Second Embodiment**

The second embodiment for scarifying the interior surface of a pipeline is depicted in Figures 5-7. The figures depict side, front and top views respectively of the second embodiment with the arm 7 mounted on the front of the vehicle.

As with the first embodiment, the apparatus comprises a vehicle 18 that propels itself along a longitudinal direction inside of a pipe, scarifying the interior surface as it travels. The apparatus is equipped with a scarifying system 19 including an arm 7 and a fluid nozzle assembly 10. The scarifying system 19 extends from the vehicle 18 to the wall of the conduit and uses fluid nozzles 15 to clean and/or profile the interior surface of the pipe.

The vehicle 18 is the same as the first embodiment and includes a chassis 2, which moves longitudinally along the bottom of the pipe floor on its track assembly 1. The tracks 1 are propelled along rollers 3 by a hydraulic motor (not shown) sitting on board the chassis 2. Although tracks 1 are included in this description of the preferred embodiment, any system capable of moving the vehicle 18 under power from the hydraulic motor will suffice.

Alternatively, if the vehicle is made sufficiently light, it may be moved manually.

The hydraulic motor is powered by an external hydraulic reservoir (not shown) coupled to the apparatus by a hydraulic coupler (not shown) also mounted on the chassis 2. It will be noted that, although a hydraulic motor is used in this embodiment, that any power providing means, both external and on-board but preferably exhaustless, may be used for this application. The direction of motion of the vehicle 18 is that of arrow 16 or 17. An on-board battery 4 powers hydraulic switches (not shown), which control the speed and direction of motion of the vehicle. The motor, hydraulic coupler and hydraulic switches are covered with plate 5 to protect their sensitive parts from debris dislodged during cleaning.

When fluid nozzles 15 are employed to clean the walls of the conduit, recoil forces may tend to disturb the vehicle trajectory. Accordingly, a number of guiding bars 20 may be attached to the chassis 2 of the vehicle 18 and telescopically extend to the walls of the pipeline. The guiding bars' wall engaging attachments, 21 move along the pipe's walls and prevent the vehicle 18 from deviating from its path. Once again, the vehicle 18 may be adjusted in width by adjusting the chassis 2, so as to position the vehicle 18 longitudinally in pipes of various sizes. Similarly to the first embodiment, the vehicle chassis 2 is equipped with a drawbar (not shown) to hold the hydraulic and high pressure fluid tethers away from the vehicle 18.

In the second embodiment, the scarifying system 19 consists of a vertical arm 7 attached to the front of the chassis 2 and a fluid nozzle assembly 10. The entire scarifying system 19 may be easily removed from the chassis 2 of the vehicle 18 in order to reduce the size of the apparatus so as to enter a sewer system through a small aperture such as a manhole. In fact, the width of the tracks may be narrowed for the same reason and, after entering the sewer pipe, the tracks may be widened to a desired width. The arm 7 includes adjusters 6 which raise the fluid coupler 9 at the center of the fluid nozzle assembly 10 to align it roughly with the center of the pipe. This alignment permits even spray on all portions of the pipeline walls. The arm 7 has a stabilizing bar 8, which helps to counteract the weight of the arm 7 in front of the vehicle 18.

The fluid nozzle assembly 10 attaches to the vertical arm 7. Fluid coupler 9 with a flow control valve is attached to an external source of fluid under pressure (not shown). The fluid is fed into exchanger/actuator 13. Referring to Figure 6, exchanger/actuator 13 causes the fluid nozzle assembly to rotate or oscillate and distributes the fluid to each branch 14 of the fluid nozzle assembly 10. The branches 14 are each counterbalanced by other branches of the plurality of branches. The direction of rotation of the fluid nozzle assembly 10 is indicated by arrows 22 and 23.

The branches 14 are laterally extendible so as to bring the fluid nozzles 15 (which are mounted on the ends

of the branches **14**) into proximity with the pipeline walls and direct them at the wall's interior surface. The meaning of the term "extendible" used here is intended to include any system by which the total length of the branches can be set so that the branches and nozzles at an end thereof are positioned proximate the interior wall of the sewer pipe. One type of extendibility of the branches is the replacement of branches with branches of a different length. Another scheme is providing branches, which can be telescopically lengthened. The apparatus can have only one branch **14**, which is equipped with a nozzle and a counterweight to the one branch **14**. The counterweight can be another branch **14** opposite the one branch or, obviously, it can be of any other shape as long as it counterbalances the branch **14**. The counterbalance could even be made up of two or more counterbalancing elements symmetrically disposed with respect to an axis of the branch **14**.

The fluid nozzles **15** discharge fluid to scarify the interior surface of the wall. Again it is understood as being obvious to one skilled in the art, that there may be a number of nozzles **15** for each branch **14**. Alternatively, one could block off any number of nozzles by simply inserting plugs into the branches to be closed off. In addition, the fluid nozzles **15** can be angled with respect to their branches so that they provide a torque that causes them to rotate. In its simplest form one can have one nozzle at the end of a first branch and a second branch with its fluid channel blocked off extending out 180 °C to the first branch to act as a counterbalance to the first

branch. Various other variants are possible and are obvious to an ordinary person skilled in the art.

As the vehicle 18 travels longitudinally along the center of the pipe floor in a direction indicated by arrows 16 and 17, the scarifying system 19 scarifies a transverse circumferential line along the interior of the pipe wall. Unlike the swaths in the first embodiment, this apparatus is capable of scarifying the entire interior surface in a single pass through the pipe. However, because a significantly larger area is being cleaned, the vehicle 18 must travel slower than it does in the first embodiment ensuring adequate coverage of the walls.

This apparatus is preferred over the first embodiment when the conduits or pipes are cylindrical in shape and the entire 360° circumference of the pipe is being cleaned.

### **The Third Embodiment**

~~The third embodiment is a combination of the first and second embodiments and is depicted in Figures 10-12, which show side, front and top views, respectively. The principal arm 7 is connected to the front of the chassis 2 as in the second embodiment, but the fluid nozzle assemblies 10 are that of the first embodiment.~~

~~The vehicle 18, chassis 2, motor (not shown), guiding bars 20, guiding bar attachments 21, battery 4, hydraulic coupler, deadman and drawbar (not shown) are substantially the same as that of the first two embodiments. The~~

~~scarifying system 19, however, is considerably different. The principal arm 7 is oriented vertically and is essentially the same as the arm in the second embodiment, but it has a plurality of additional subsidiary arms 11 which extend transversely from the center of the principal arm 7. The adjusters 6 move vertically to align the center of the subsidiary arms 11 with the center of the pipe. The subsidiary arms 11 are telescopically adjustable so that they can extend transversely to the inner surface of the pipeline walls. A fluid coupler 9 with flow control valve receives fluid under pressure from an external source (not shown). An exchanger/actuator 33 simultaneously rotates or oscillates the subsidiary arms 11 and distributes the fluid. At the end of each subsidiary arm 11 is a fluid nozzle assembly 10 that is basically the same as that of the first embodiment. Each fluid nozzle assembly 10 has a secondary fluid coupler 24, an exchanger/actuator 13, symmetrical branches 14, and fluid nozzles 15.~~

~~The vehicle 18 travels longitudinally along the center of the pipe in a direction indicated by arrows 16 or 17, while the subsidiary arms 11 rotate or oscillate in the direction of arrow 22 or 23, moving the fluid nozzle assemblies 10 laterally across the inner circumference of the pipeline wall. The fluid nozzle assemblies 10 are simultaneously rotating or oscillating such that they are cleaning a swath similar to the first embodiment, but the swath is laterally oriented.~~

~~The third embodiment (like the second) is most useful for cleaning the entire circumference of the interior of a~~

~~cylindrical pipe. However, the wide swath enabled by incorporating the fluid nozzle assembly 10 from the first embodiment permits the vehicle 18 to travel faster down the pipeline floor and still maintain adequate coverage of the walls.~~

### **The Third Embodiment**

The third embodiment is a combination of the first and second embodiments and is depicted in Figures 10-12, which show side, front and top views, respectively. The principal arm 7 is connected to the front of the chassis 2 as in the second embodiment, but the spray nozzle assemblies 10 are that of the first.

The vehicle 18, chassis 2, motor (not shown), guiding bars 20, guiding bar attachments 21, battery 4, hydraulic coupler, deadman and drawbar (not shown) are substantially the same as that of the first two embodiments. The cleaning system 19, however, is considerably different. The principal arm 7 is oriented vertically and is essentially the same as the arm in the second embodiment, but it has a plurality of additional subsidiary arms 11 which extend transversely from the center of the principal arm 7. The adjusters 6 move vertically to align the center of the subsidiary arms 11 with the center of the pipe. The subsidiary arms 11 are telescopically adjustable so that they can extend transversely to the inner surface of the pipeline walls. A fluid coupler 9 with flow control valve receives fluid under pressure from an external source (not shown). An exchanger/actuator 33 simultaneously rotates or

oscillates the subsidiary arms 11 and distributes the fluid. At the end of each subsidiary arm 11 is a nozzle assembly 10 that is basically the same as that of the first embodiment. Each nozzle assembly 10 has a secondary fluid coupler 24, an exchanger/actuator 13, symmetrical branches 14, and spray nozzles 15.

The vehicle 18 travels longitudinally along the center of the pipe in a direction indicated by arrows 16 or 17, while the subsidiary arms 11 rotate or oscillate in the direction of arrow 22 or 23, moving the spray nozzle assemblies 10 laterally across the inner circumference of the pipeline wall. The spray nozzle assemblies 10 are simultaneously rotating or oscillating such that they are cleaning a swath similar to the first embodiment, but the swath is laterally oriented.

The third embodiment (like the second) is most useful for cleaning the entire circumference of the interior of a cylindrical pipe. However, the wide swath enabled by incorporating the nozzle assembly 10 from the first embodiment permits the vehicle 18 to travel faster down the pipeline floor and still maintain adequate coverage of the walls.

#### **The Fourth Embodiment**

~~The fourth embodiment is also a combination of the first and second embodiments, which is particularly adapted to clean the bottom surfaces of pipelines. The fourth embodiment is depicted in Figures 14-16, which show side,~~

front and top views respectively. The principal arm 7 is connected to the front of the chassis 2 as in the second embodiment but the fluid nozzle assembly 10 is that of the first.

The vehicle 18, chassis 2, motor (not shown), guiding bars 20, guiding bar attachments 21, battery 4, hydraulic coupler, deadman and drawbar (not shown) are substantially the same as those of the first two embodiments. The scarifying system 19, however, is considerably different. The principal arm 7 is oriented vertically and is essentially the same as the arm in the second embodiment, but it has an additional subsidiary arm 11, which extends forwardly from the principal arm 7. The adjusters 6 move vertically up the principal arm 7 to adjust the height of the subsidiary arm 11. The subsidiary arm 11 holds the fluid nozzle assembly 10, and the fluid coupler 9 with flow control valve which are basically the same elements as in the first embodiment. The fluid nozzle assembly 10 is outfitted with an exchanger actuator 13, symmetrical branches 14, and fluid nozzles 15. Note: these elements are shown in Figures 8 and 9. A stabilizing bar 8 extends from the front end of the subsidiary arm 11 to the top end of the principal arm 7 to help stabilize the front of the apparatus when it is carrying the additional weight of the fluid nozzle assembly 10.

As the vehicle 18 travels longitudinally along the center of the pipe floor in a direction indicated by arrows 16 and 17, the cleaning system 19 cleans a transverse circumferential line along the interior of the pipe wall.

~~Unlike the swaths in the first embodiment, this apparatus is capable of cleaning the entire interior surface in a single pass through the pipe. However, because a significantly larger area is being cleaned, the vehicle 18 must travel more slowly than it does in the first embodiment ensuring adequate coverage of the walls.~~

~~An additional safety feature not shown in the drawings is a "deadman" which is a safety switch operative to cut off the high pressure from the moving parts of the cleaning system 19. The deadman is useful in both emergency situations and when minor adjustments must be made to the apparatus during a job.~~

~~This apparatus is preferred over the first embodiment when the conduits or pipes are cylindrical in shape and the entire 360° circumference of the pipe is being cleaned.~~

#### **The Fourth Embodiment**

The fourth embodiment is also a combination of the first and second embodiments, which is particularly adapted to clean the bottom surfaces of pipelines. The fourth embodiment is depicted in Figures 14-16, which show side, front and top views respectively. The principal arm 7 is connected to the front of the chassis 2 as in the second embodiment but the nozzle assembly 10 is that of the first.

The vehicle ~~19~~<sup>18</sup>, chassis 2, motor (not shown), guiding bars 20, guiding bar attachments 21, battery 4, hydraulic coupler, deadman and drawbar (not shown) are

substantially the same as those of the first two embodiments. The cleaning system ~~1819~~, however, is considerably different. The principal arm 7 is oriented vertically and is essentially the same as the arm in the second embodiment, but it has an additional subsidiary arm 11, which extends horizontally from the principal arm 7. The adjusters 6 move vertically up the principal arm 7 to adjust the height of the subsidiary arm 11. The subsidiary arm 11 holds the fluid nozzle assembly 10, and the fluid coupler 9 with flow control valve which are basically the same elements as in the first embodiment. The fluid nozzle assembly 10 is outfitted with an exchanger actuator 13, symmetrical branches 14, and fluid nozzles 15. Note: these elements are shown in Figures 8 and 9. A stabilizing bar 8 extends from the front end of the subsidiary arm 11 to the top end of the principal arm 7 to help stabilize the front of the apparatus when it is carrying the additional weight of the nozzle assembly 10.

The vehicle 18 travels longitudinally along the center of the pipe in a direction indicated by arrows 16 or 17, while the branches 14 of the nozzle assembly 10 rotate or oscillate, moving the spray nozzles 15 around on the bottom surface of the pipeline. The spray nozzles cut a swath similar to the first embodiment except that the swath is on the bottom surface of the pipe rather than at a radial angle. The fourth embodiment is specifically suited for cleaning the bottom surface of a pipeline.

Referring to Fig. 17, the nozzle assembly 36 comprises a single oscillating arm or branch 42 having a nozzle 44 at a distal end and coupled at another end to a motor assembly

(not shown) contained within a chassis 38. A high pressure water hose 46 couples to the branch within the chassis 38 and an electrical cable 48 couples to the motor assembly (not shown). The chassis 38 is mounted on a moveable vehicle 40 that carries it along an interior of a pipe. The length of the arm or branch 42 is selected so that the nozzle 44 is proximate an interior surface of the pipe to be scarified.

In operation, the vehicle 40 is indexed from one position to the next and at each position the arm makes a complete sweep from one side to the next. In order to cover a wider area, the nozzle 44 could be made to rotate about an axis at an angle to its own axis. Alternatively, a nozzle assembly with one or more nozzles rotating about an axis through the arm 42 could be employed. In order to cover a maximum of pipe wall area, the chassis 38 has to be mounted as close to the bottom of the pipe as possible.

Accordingly, while this invention has been described with reference to illustrative embodiments, this description is not intended to be construed in a limiting sense. Various modifications of the illustrative embodiments, as well as other embodiments of the invention, will be apparent to persons skilled in the art upon reference to this description. It is therefore contemplated that the appended claims will cover any such modifications or embodiments as fall within the true scope of the invention.